iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** III **Month of publication:** March 2025

DOI: https://doi.org/10.22214/ijraset.2025.67902

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue III Mar 2025- Available at www.ijraset.com

Analysis and Design of Multistorey Building using STAAD Pro

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Abstract: In this project, an attempt is made to analyze and design a multi-storey building (G+3, residential building) using STAAD PRO software. For the analysis and design of the multi-storey building, the possible loads—such as dead load, live load, and wind load—are considered for static analysis. All 2D work is done using AutoCAD, while the analysis and design are carried out in STAAD PRO.
This work aims to demonstrate the variation in reinforcement for a similar type of structure with the same parameters but using different types of concrete grades.
Keywords: Analysis, Design, STAAD PRO, (G+3) Residential building, Static Analysis.

I. INTRODUCTION

Urbanization and the increasing demand for residential spaces. Structural analysis and The construction of multi-storeyed buildings has become a necessity due to rapid design play a crucial role in ensuring the safety, stability, and economic viability of such buildings. STAAD.Pro, a widely used structural analysis and design software, provides an efficient way to analyze and design complex structures while adhering to relevant building codes and standards.
This project focuses on the design and analysis of a G+3 (Ground + 3 Storey) multi-storeyed residential building using STAAD.Pro. The building will be designed as **a** reinforced concrete framed structure to withstand dead loads, live loads, and wind loads as per the Indian Standards (IS) codes.

II. LITERATURE REVIEW

Adhiraj A. Wadekar, Ajay G. Dahake (2020) this paper deal with Analysis and Design of a Multi-Storey Building by Using STAAD Pro. They Demonstrated the effectiveness of STAAD.Pro in analyzing and designing multi-storey buildings, ensuring structural safety and compliance with standards.
Anjana Gupta (2021) this paper deal with Analysis and Design of Multi-Storey Building by Using STAAD Pro. They Investigated the efficacy of STAAD.Pro in analyzing and designing multi-storey buildings, emphasizing its utility in handling various load combinations.
Sakib Salam Sofi (2022) this paper work on Analysis and Design of Multistorey Building by Using STAAD Pro Software. They Demonstrated the effectiveness of STAAD.Pro in the analysis and design of multistorey buildings, ensuring structural safety and compliance with standards.
A.Kumar, B. Patel (2023) this paper deal with Optimization of Multi-Storey Building Design using STAAD Pro. They conclude that STAAD Pro is shown to significantly reduce design time and material costs while maintaining structural integrity under seismic and wind loads.
Yeswanth Kumar (2024) this paper deal on A Review on Design of G+11 Storied Building Using STAAD-Pro. They Highlighted STAAD.Pro's ability to handle complex load combinations in G+11 multi-storey building designs efficiently.

A. Objective

- AutoCAD 2D plan of building.
- Analysis & Design of the structure(G+3) in STAAD.Pro.
- Reinforcement Details Based on Concrete Grades.

III. METHODOLOGY

In this project, we first create a 2D plan of the structure (G+3, residential building) using AutoCAD software. Next, we develop a model of the structure in STAAD PRO software and assign all the necessary properties to the structure. After that, we calculate the loads, such as dead load, live load, and wind load, as per IS-875 (Part 1), IS-875 (Part 2), and IS-875 (Part 3). All the loads are then assigned to the structure, and we proceed with the analysis to check the stability of the structure. Finally, we design the RCC structure as per IS-456:2000 in STAAD PRO. The details of the structure are provided below.

A. Geometric Parameters

Beam size : 250 mm X 280 mm
Column size : 250 mm X 300 mm
Slab thickness : 125 mm
Height of main and partition wall = 3 m
Height of parapet wall = 1.2 m
Main wall thickness : 230 mm
Partition wall thickness : 120 mm
Parapet wall thickness : 120 mm
Thickness of floor finish : 50 mm
Unit weight of concrete : 25 KN/m^3
Unit weight of cement mortar : 20 KN/m^3
Unit weight of brick masonry : 20 KN/m^3

B. Load Calculations

- Dead load as per IS-875 (Part-1)

Self weight of slab = slab thickness X unit wt. of RCC = 3.125 KN/m^2
Floor finish load = thickness of F.F. X unit wt. of cement mortar = 1 KN/m^2
Total load = 3.125 + 1 = 4.125 KN/m^2 (apply on the floors)
Partition wall load = thickness of partition wall X height X unit wt. of brick masonry = 7.2 KN/m (apply on the beams)
Main wall load = thickness of main wall X height X unit wt. of brick masonry = 13.8 KN/m (apply on beams)
Parapet wall load = thickness of parapet wall X height X unit wt. of brick masonry = 2.88 KN/m (apply on beams)

- Live load

For residential building

Occupancy	Loading
All rooms & kitchen	2 KN/m^2
Toilet & bathrooms	2 KN/m^2
Corridors, passages, & staircase	3 KN/m^2
Balconies	3 KN/m^2

- Wind load calculation

[$P_Z = 0.6\ V_Z^2$] ……eq1
P_Z = WIND SPEED
V_Z = Design wind speed at any height
[$V_Z = V_B$ X K_1 X K_2 X K_3] ……eq2
V_B = Basic wind speed of the region = 47
K_1 = Probability factor (risk coefficient) = 1
K_2 = Terrian, height & structure size factor = 1.05(at 10m) & 1.075(at 13m)
K_3 = Topography factor = 1
By putting all above values in eq1 & eq2 we get
P_Z = 1.416 KN/m2 (at 10m)
P_Z = 1.531 KN/m2 (at 13m)

- Load Combinations

1.5 (DL + LL)
1.2 (DL +LL+WL X)
1.2 (DL +LL+WL Z)
0.9 (DL +LL+WL X)
0.9 (DL +LL+WL Z)

IV. ANALYSIS AND DESIGN

A. *Introduction of STAAD PRO*

It is one of the effective software which is used for the purpose of analysis and design of structure by the structural engineers.

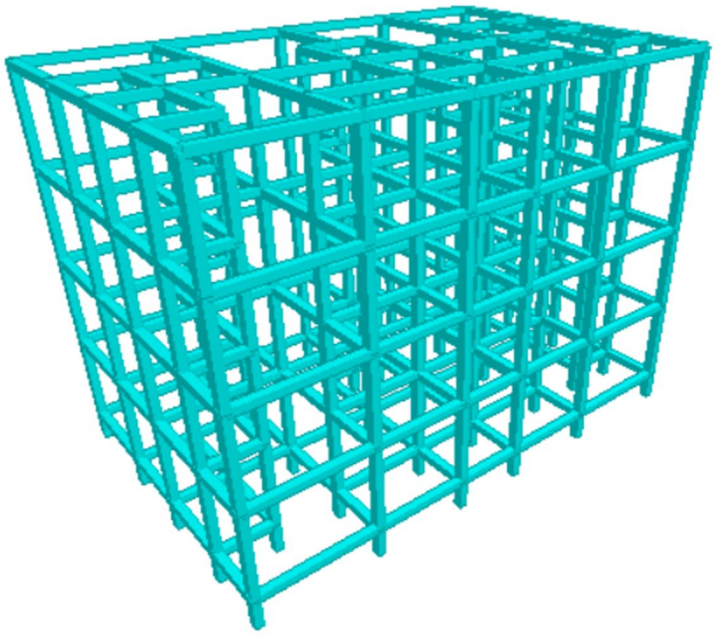


Fig. A : Structure

B. *Reactions summary for M25 & Fe415*

All Summary

	Node	L/C	Horizontal X mm	Vertical Y mm	Horizontal Z mm	Resultant mm	Rotational rX rad	rY rad	rZ rad
Max X	189	6 1.2(DL+LL+	**0.788**	-1.971	-0.563	2.196	-0.000	-0.000	-0.001
Min X	200	6 1.2(DL+LL+	**-0.788**	-1.971	-0.563	2.196	-0.000	0.000	0.001
Max Y	183	1 WL X	0.434	**0.007**	-0.044	0.436	-0.000	-0.000	-0.000
Min Y	204	5 DL+LL(1.5)	-0.000	**-4.829**	-0.907	4.914	0.001	0.000	-0.000
Max Z	47	5 DL+LL(1.5)	0.125	-0.379	**0.042**	0.402	0.000	-0.000	-0.001
Min Z	215	5 DL+LL(1.5)	-0.005	-2.115	**-0.972**	2.328	-0.001	-0.000	-0.000
Max rX	204	5 DL+LL(1.5)	-0.000	-4.829	-0.907	4.914	**0.001**	0.000	-0.000
Min rX	203	5 DL+LL(1.5)	-0.000	-2.951	-0.943	3.098	**-0.002**	0.000	0.000
Max rY	216	6 1.2(DL+LL+	-0.087	-1.604	-0.581	1.708	-0.000	**0.000**	0.001
Min rY	205	6 1.2(DL+LL+	0.087	-1.604	-0.581	1.708	-0.000	**-0.000**	-0.001
Max rZ	199	5 DL+LL(1.5)	-0.109	-2.428	-0.611	2.507	0.001	-0.000	**0.001**
Min rZ	191	5 DL+LL(1.5)	0.109	-2.428	-0.611	2.507	0.001	0.000	**-0.001**
Max Rs	204	5 DL+LL(1.5)	-0.000	-4.829	-0.907	**4.914**	0.001	0.000	-0.000

C. Reaction Summary for M20 &Fe415

			Horizontal	Vertical	Horizontal	Resultant	Rotational		
	Node	L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
Max X	189	6 COMBINATI	**0.639**	-2.890	-0.229	2.968	-0.000	-0.000	-0.000
Min X	200	6 COMBINATI	**-0.639**	-2.890	-0.229	2.968	-0.000	0.000	0.000
Max Y	183	1 WL X	0.434	**0.007**	-0.044	0.436	-0.000	-0.000	-0.000
Min Y	204	5 COMBINATI	-0.000	**-6.374**	-0.384	6.386	0.001	0.000	-0.000
Max Z	192	3 DL	0.037	-3.165	**0.073**	3.166	0.000	0.000	-0.000
Min Z	203	5 COMBINATI	-0.000	-3.348	**-0.417**	3.374	-0.002	0.000	0.000
Max rX	204	5 COMBINATI	-0.000	-6.374	-0.384	6.386	**0.001**	0.000	-0.000
Min rX	203	5 COMBINATI	-0.000	-3.348	-0.417	3.374	**-0.002**	0.000	0.000
Max rY	216	1 WL X	-0.026	0.002	-0.044	0.051	0.000	**0.000**	0.000
Min rY	205	1 WL X	0.026	0.002	-0.044	0.051	0.000	**-0.000**	-0.000
Max rZ	199	5 COMBINATI	-0.136	-3.805	-0.187	3.812	0.001	-0.000	**0.002**
Min rZ	191	5 COMBINATI	0.136	-3.805	-0.187	3.812	0.001	0.000	**-0.002**
Max Rs	204	5 COMBINATI	-0.000	-6.374	-0.384	**6.386**	0.001	0.000	-0.000

D. Beam Design for M25 & Fe415

```
                    SUMMARY OF PROVIDED REINF. AREA
-------------------------------------------------------------------------------
SECTION       0.0 mm       838.7 mm      1677.5 mm      2516.2 mm      3355.0 mm
-------------------------------------------------------------------------------
 TOP        4-10í          2-10í          2-10í          3-10í          3-10í
REINF.    1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)

BOTTOM      2-12í          3-12í          3-12í          3-12í          3-12í
REINF.    1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)     1 layer(s)

SHEAR    2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í  2 legged  8í
REINF.  @ 110 mm c/c   @ 110 mm c/c   @ 110 mm c/c   @ 110 mm c/c   @ 110 mm c/c
-------------------------------------------------------------------------------
```

E. Column Design for M25 & Fe415

```
          C O L U M N   N O.    425   D E S I G N   R E S U L T S

      M25                    Fe415 (Main)              Fe415 (Sec.)

LENGTH:  3000.0 mm   CROSS SECTION:  300.0 mm X  250.0 mm  COVER: 40.0 mm

** GUIDING LOAD CASE:    5 END JOINT:   191  SHORT COLUMN

-----------------------------< PAGE 749 Ends Here >-------------------------
 STAAD SPACE                                                -- PAGE NO.  750


REQD. STEEL AREA    :      1051.23 Sq.mm.
REQD. CONCRETE AREA:     73948.77 Sq.mm.
MAIN REINFORCEMENT : Provide  12 - 12 dia. (1.81%,    1357.17 Sq.mm.)
                     (Equally distributed)
TIE REINFORCEMENT  : Provide  8 mm dia. rectangular ties @ 190 mm c/c
```


F. Beam design for M20 & Fe415

SUMMARY OF PROVIDED REINF. AREA

SECTION	0.0 mm	838.7 mm	1677.5 mm	2516.2 mm	3355.0 mm
TOP REINF.	7-10í 1 layer(s)	2-10í 1 layer(s)	2-10í 1 layer(s)	3-10í 1 layer(s)	5-10í 1 layer(s)
BOTTOM REINF.	2-12í 1 layer(s)	3-12í 1 layer(s)	3-12í 1 layer(s)	3-12í 1 layer(s)	3-12í 1 layer(s)
SHEAR REINF.	2 legged 8í @ 110 mm c/c	2 legged 8í @ 110 mm c/c	2 legged 8í @ 110 mm c/c	2 legged 8í @ 110 mm c/c	2 legged 8í @ 110 mm c/c

G. Column design for M20 & Fe415

C O L U M N N O. 425 D E S I G N R E S U L T S

M20 Fe415 (Main) Fe415 (Sec.)

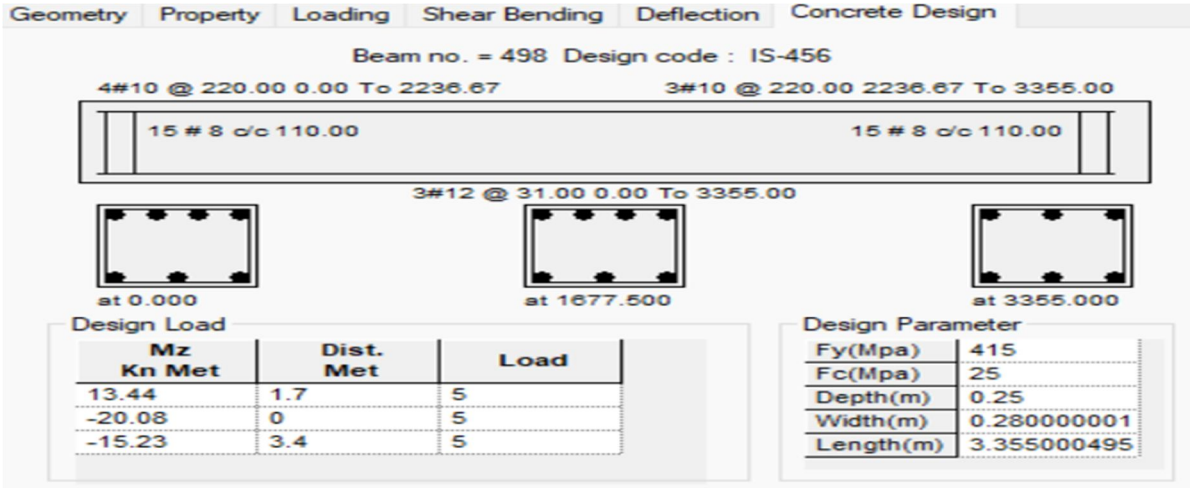
LENGTH: 3000.0 mm CROSS SECTION: 300.0 mm X 250.0 mm COVER: 40.0 mm

** GUIDING LOAD CASE: 5 END JOINT: 191 SHORT COLUMN

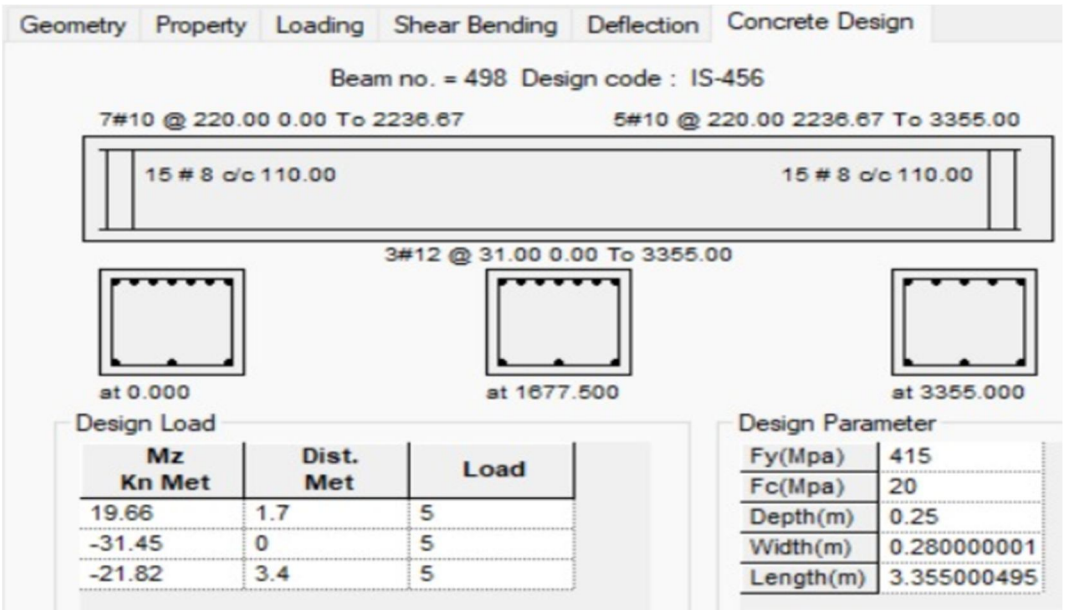
REQD. STEEL AREA : 1695.40 Sq.mm.
REQD. CONCRETE AREA: 73304.60 Sq.mm.
MAIN REINFORCEMENT : Provide 16 - 12 dia. (2.41%, 1809.56 Sq.mm.)
(Equally distributed)
TIE REINFORCEMENT : Provide 8 mm dia. rectangular ties @ 190 mm c/c

H. Comparison of Reinforcement based on Different Concrete Grade

- When M25 & Fe415 is used



- When M20 & Fe415 is used



V. RESULT AND DISCUSSION

We got the certain results from the above design, analysis and comparison for the grade of concrete. They are:

1) Both the structures are safe and can be constructed.

2) The below table describe the warnings given for M20 and Fe415:

No. of beams and column under warning	Warning given
61, 66, 74, 76, 82, 84, 85, 89, 163, 173	Unable to accommodate required reinforcement.
67, 70, 73, 79, 83, 157, 160, 169,	Reinforcement % exceeds maximum limits

3) M25 concrete grade is better than M20 concrete grade for construction work because the permissible stresses indicate that M25 concrete is superior to M20. Additionally, the required reinforcement increases as the grade of concrete decreases.

4) Our structure is more stable when we use M25 grade of concrete instead of M20. Additionally structure is economical.

VI. CONCLUSION

This study concludes that the structure designed using the above data is safe, whether M20 or M25 grade concrete is used. The comparison indicates that the required reinforcement and the cost of the structure increase as the grade of concrete decreases. The analysis and design are easier when using STAAD Pro software, which also saves time.

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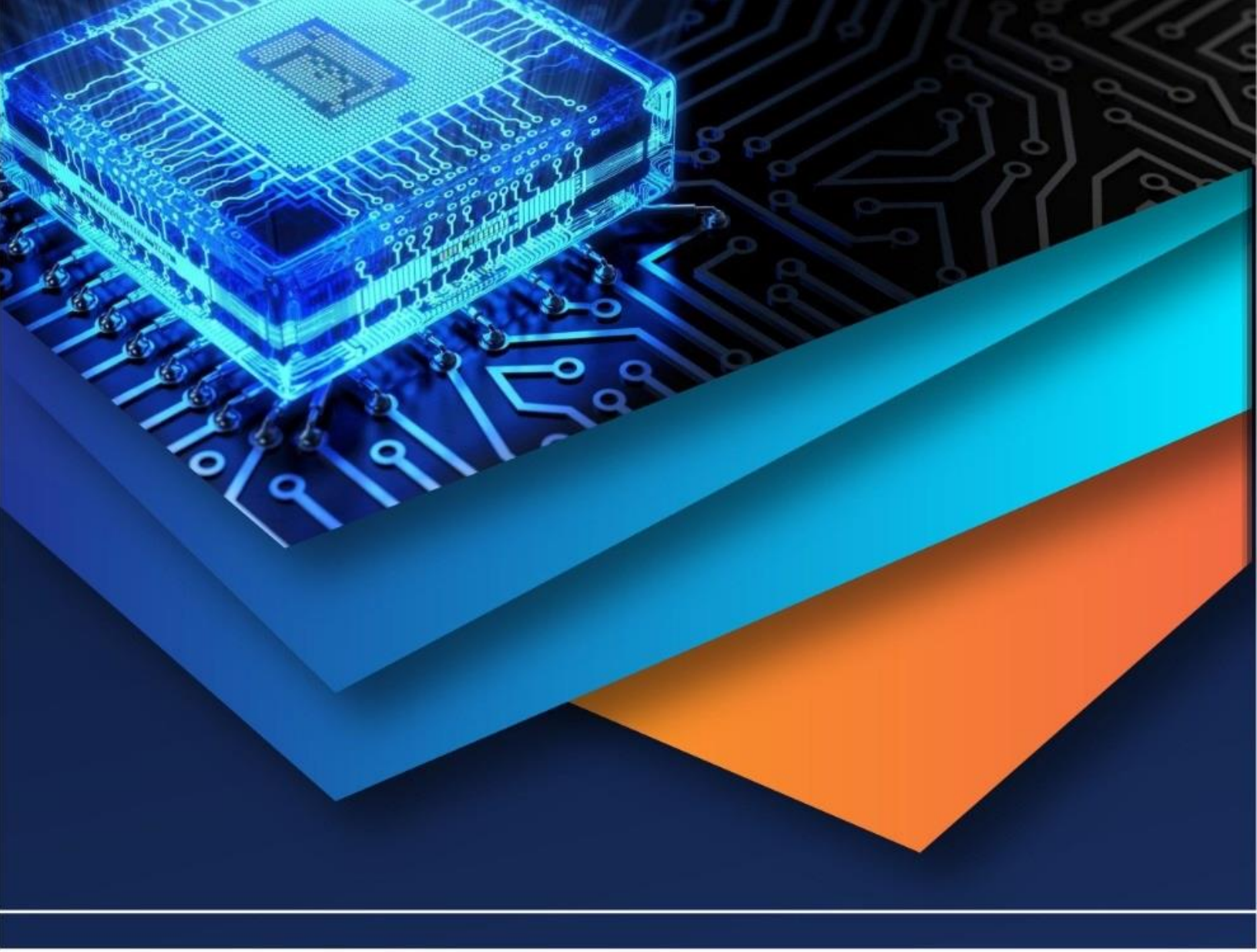

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